Technical Paper

5/RT/96 **December 1996**

Non-Traded, Traded and Aggregate Inflation in Ireland: Further Evidence*

by

Geoff Kenny and Donal McGettigan

* Paper presented at the *Money, Macro and Finance Research Group*, 28th Annual Conference, London Business School, 4-6 September 1996 and the *Dublin Economics Workshop*, 22nd November 1996 . The authors would like to thank participants at the workshop and colleagues in the Bank for helpful suggestions on an earlier draft. The views expressed in the paper are not necessarily those held by the Bank and are the personal responsibility of the authors. Comments and criticisms are welcome.

Economic Analysis, Research and Publications Division, Central Bank of Ireland, P.O. Box 559, Dublin 2.

Abstract

The purpose of this paper is to shed light on some of the main unresolved issues surrounding the determination of Irish inflation. The econometric methodology is largely data-based and can be viewed as testing the long-run validity of i) a pure wage mark-up model ii) a pure small open economy (SOE) model and iii) a hybrid model which fuses elements of i) and ii). The analysis covers the period since Ireland joined the exchange rate mechanism of the European Monetary System, i.e. 1979:Q1 to 1995:Q3. Multivariate cointegration techniques, together with a set of impulse response functions, are employed in order to clearly distinguish the long- and the short-run information in the data. Our overall results highlight the empirical relevance of the distinction between traded and non-traded prices. In the case of traded prices, full purchasing power parity (PPP) as a long-run equilibrium relationship was found to be consistent with the data (with full pass-through taking about 3 to 4 years). In the case of non-traded prices the data reject strict long-run PPP. Non-traded prices were, however, shown to cointegrate with a combination of world traded prices and the exchange rate. As would be expected, aggregate price results occupy an intermediate position, with full PPP being almost acceptable. However, a stationary combination of aggregate prices, world traded prices and the exchange rate is strongly accepted by the data. Finally, the paper demonstrates that strong bi-directional causality exists between prices and wages.

1. Introduction

This paper attempts to shed light on some of the main unresolved issues surrounding the determinants of Irish inflation. Central to the empirical approach adopted here, is the construction of a new datatset which permits separate analysis of the price determination processes in the traded and non-traded sectors of the economy. This approach is particularly associated with the Scandinavian model of inflation. The econometric methodology is largely data-based and can be viewed as testing the long-run validity of i) a wage mark-up model ii) a pure price-taking small open economy (SOE) model and iii) a hybrid model which fuses element of i) and ii). Multivariate cointegration techniques, as well as impulse response functions, are employed in order to clearly distinguish the long- and the short-run information in the data. Overall, the results underline the appropriateness of disaggregating in an empirical analysis of inflation in an SOE. Although there is evidence that the hybrid model may be most appropriate for both the traded and non-traded sectors of the economy, only in the former sector is the strict purchasing power parity relationship (PPP) acceptable. As would be expected, aggregate prices occupy an intermediate position, with tentative evidence emerging in favour of full PPP. The layout of the remainder of the paper is as follows: In Section 2, some of main underlying theoretical and empirical issues are discussed. Section 3 discusses the econometric methodology and presents results from the estimation of traded, non-traded and aggregate wage-price-exchange rate systems. Finally, Section 4 summarises and concludes.

2. Underlying Theoretical Issues

Economic theory offers a host of possible explanations for inflation. Closed economy macroeconomics, for example, suggests both monetarist and also more traditional Phillips curve explanations. Monetary theories stress the unique role of money as an independent and ultimate cause of inflation. Phillips curve theory, on the other hand, places an emphasis on variables which are thought to have a more proximate relationship with inflation, e.g. the unemployment rate relative to its “natural” rate. In addition, both schools emphasise the role of price expectations in the inflationary process. Other, often cited, and related explanations of inflation include the role of demand-pull and cost-push factors, even though the usefulness of this distinction has recently been questioned. There is, as yet, no generally accepted model of the inflationary process, however. It is perhaps unsurprising, therefore, that when the analysis is extended to the more interesting case of an open economy, even less agreement is apparent in both the empirical and theoretical work. For an open economy, the set of potentially relevant variables expands dramatically[1]. Inflation dynamics in an open economy are, of course, highly dependent on the type of exchange rate regime pursued. This paper is concerned with the inflationary process in Ireland, a classic example of a small open economy, where the exchange rate regime has switched from a strict peg with sterling to the quasi-fixed ERM system.

Theories of SOE Inflation

A particularly simple approach to modelling SOE inflation relies on the assumption of purchasing power parity (PPP). Absolute PPP states that the price of a basket of goods in one country (P_t) will equal the price of the same basket of goods in a foreign country (P_t*) converted at the relevant nominal exchange rate (E_t). When we allow for a constant proportionate relationship between both sets of prices PPP can be written as (expressed in logs)[2]:

$$P_t = \text{Constant} + E_t + P_t^*$$

or, when all variables are differenced:

$$\Delta P_t = \Delta E_t + \Delta P_t^* \qquad (1)$$

While some disagreement still exists, there is widespread evidence in favour of PPP as a <u>long-run</u> hypothesis (see, for example, Froot and Rogoff, 1995, for a recent survey). The implications of (1) for inflation analysis in an SOE depend crucially on what happens to the exchange rate. The SOE model interprets (1) as a complete long-run theory of domestic inflation. In a fixed exchange rate regime ($\Delta E_t = 0$), under the assumption of smallness (i.e. price-taking behaviour), it follows from (1) that the

[1] Rowlatt (1992), for example, in a comprehensive empirical study of UK inflation develops a reduced form equation which contains approximately 50 explanatory variables. See Rowlatt (1992) Chapter 7, Table 7.1 .

[2] Such a constant differential between price levels may be caused by transactions costs, index problems, etc.

domestic rate of inflation will be determined abroad[3]. In this extreme case, inflation in a small open economy is taken as largely given and outside its control[4]. Under a flexible exchange rate regime, however, (1) falls far short of a complete long-run theory of inflation[5]. If PPP holds and the nominal exchange rate is depreciating over time, it implies that domestic factors are contributing to SOE inflation in the long run[6]. In contrast to the fixed exchange rate case, this would imply that the analysis of many of the factors mentioned above (e.g. excessive wage pressure, excessive money creation) would also warrant consideration.

The above PPP approach to modelling inflation for SOEs, while generally accepted as a long-run proposition, is highly aggregate, and ignores potentially interesting differences in price determination behaviour in the sheltered and exposed sectors of a SOE. A more refined view of inflation has been put forward by the Scandinavian school[7]. This perspective emphasises separate price determination channels for both sectors of the economy. Under a fixed exchange rate, traded inflation is assumed to conform with the implications of PPP under the assumptions of smallness, i.e. it is taken as given. Non-traded prices, however, are expressed as a mark-up over wage costs adjusted for productivity. Under the assumptions of wage equalisation across sectors and higher productivity in the traded sector than elsewhere, it can be shown

---

[3] If the nominal exchange rate is fixed, and PPP holds, then under the assumption of price-taking behaviour (smallness), it is plausible to assume that causation runs from P^* to P rather than *vice versa*. In this case, domestic influences over inflation are transitory, at most.

[4] The international monetary approach to inflation, which is particularly associated with, for example, Johnson (1972a, 1972b), also relies on the assumption of PPP. It reserves a special independent role for money in the inflationary process, however. In this paper we leave aside the thorny issue of the direction of causation between money and inflation, and instead take foreign prices as given.

[5] A complete theory of inflation would, for example, have to examine the factors determining nominal exchange rate movements.

[6] Such a situation could be caused either by domestic inflationary policies or external deflationary policies which have not been followed at home. As such the information provided by the nominal exchange rate under such circumstances is of domestic inflation policies relative to those prevailing abroad, rather than on absolute inflation performance. Examination of the nominal exchange rate over the 1979-1995 period suggests that in the early 1980s, given the depreciating nominal exchange rate, domestic factors were adding significantly to external inflationary pressures. By contrast, since the mid-1980s the relative stability of the exchange rate indicates that domestic factors did not add to external inflation pressures.

[7] See, for instance, Edgren, Faxen and Odhner (1973), Aukrust (1977) and Lindbeck (1979) for early examples of this approach and Mellis (1993), De Gregorio, Giovannini and Wolf (1994) for more recent usage of the traded/non-traded price determination breakdown.

that a permanent wedge can be driven between SOE inflation and the rate of inflation persisting abroad despite the exchange rate being fixed[8].

Studies of inflation in Ireland

Most studies of Irish inflation have directly reflected the long-run implications of the SOE model discussed above. The literature can, however, be divided into two distinct phases; that research dealing with inflation prior to joining the European Monetary System (EMS) in 1979, when we were firmly pegged to sterling, and that subsequent to our entry. In the earlier period, there was a widespread acceptance that Irish inflation was externally determined in the UK, and that the authorities had no independent control over it. In a Phillips curve analysis, Geary (1976a) finds that the UK retail price index directly influenced Irish inflation in the pre-ERM period and he finds little support for the view that Irish inflation is determined by domestic excess demand. In an earlier paper, Geary and Jones (1975) report a similar finding. With the general acceptance of the SOE model, the main disagreement centred upon the speed of adjustment to world inflation. Geary (1976b) found that it took at least eight quarters for UK inflation to be transmitted to the Irish economy. These long lag structures were, however, subsequently refuted in Bradley (1977) who found almost no "attenuation" in the transmission of the long-term and annual components of the UK RPI into the Irish CPI. Later evidence supporting the assumptions of the SOE model in this period was provided in Browne (1982, 1983), who found support for the SOE price-taking hypothesis for Irish exporters and importers. Browne (1984) also presents results which validate the SOE model in that he cannot reject the hypothesis that UK monetary policy, operating through both the current and capital account, has a long-run one-for-one effect on the Irish rate of inflation.

The decision to break the link with sterling in 1979 and peg the Irish pound directly to the DM created an environment in which the Irish rate of inflation could deviate from that of the countries to which it was tied[9]. The new regime was, for example, far short

[8] See the treatment in Lindbeck (1979) for a complete development of the Scandinavian model of SOE inflation, where the analysis is also extended to allow for temporary demand effects.

[9] We have already seen how Irish inflation, in a fixed exchange rate regime, could deviate from that of its partner countries in the presence of productivity differentials. The new regime, with its quasi-fixed exchange rates, allowed even greater divergences to occur.

of a complete monetary union. The exchange rate, while effectively pegged to the DM within a narrow band, was no longer rigidly fixed. Thus, there was always the possibility of adjusting the parities within the system and economic agents would take this into account in formulating their price expectations. Furthermore, since the UK stayed outside the ERM up until October 1990, the Irish pound began to float vis-à-vis the economy with which it conducted a large proportion of its trade. Ireland could, for example, avoid "importing" UK inflation by allowing the Irish pound/sterling exchange rate to appreciate[10]. In this new exchange rate environment, a much greater potential existed for domestic factors to strongly influence the Irish rate of inflation, even in the long run. Browne (1984) found that changes in domestic monetary policy had an enduring effect on Irish inflation in the post-EMS period. O'Connell and Frain (1989) also attribute a significant role to domestic excess money creation in explaining Irish inflation between 1977 and 1985. While Callan and Fitzgerald (1989) find wages to be insignificant in the long-run determination of Irish inflation, Fountas, Lally and Wu (1995) find evidence in favour of a role for them.

As regards external factors, Browne (1984) found little evidence of a strong role for German money stock in the determination of Irish inflation. Browne's analysis was, however, restricted in its use of an admittedly small data set. More recent studies, such as Callan and FitzGerald (1989) have found greater evidence of a long-run role for German prices. In contrast, however, Leddin and Hodnett (1995), employing consumer price series over the 1960-1994 period, find no evidence to support cointegration between Irish and German prices. Finally, some recent papers have fuelled controversy regarding the role of the exchange rate in the determination of Irish prices. The SOE model implies that - from a position of equilibrium - any change in the exchange rate will feed through one-for-one into domestic inflation[11]. The model therefore implies that no long-run competitive gain can be reaped from a devaluation. Flynn (1986), and Honohan and Flynn (1986) provide evidence in favour of this proposition, using data from the 1970s and 1980s. In contrast to the above studies, a

[10] This is exactly what happened in the late 1980s, when the UK experienced a sharp rise in inflation.
[11] If a country's real exchange rate is overvalued relative to equilibrium, a devaluation may merely result in equilibrium being achieved. Devaluation under such circumstances may, therefore, merely validate past inflation pressures rather than result in new ones. Nevertheless, under such circumstances, it is easy to envisage an inflation spiral taking hold.

subsequent analysis by O'Connell and Frain (1989) finds that only half of the change in the exchange rate is passed through to domestic prices.

Overall, as the above review makes clear, there now exists considerably less agreement on the causes of Irish inflation than was the case prior to joining the EMS. Accordingly, it is the aim of this paper to provide answers to some of the unresolved issues which have arisen, i.e. whether Irish inflation has been primarily influenced by internal or external factors, the role of the exchange rate and the importance of wages in the inflation process. In order to do this, we disaggregate prices into their traded and non-traded components, along the lines of the Scandinavian model and examine whether separate price determination processes exist. Following on from this, we proceed to uncover the main causes of aggregate Irish inflation.

3. Econometrics

The econometric approach which appears to be most suited to the types of questions posed above is the so-called "Johansen procedure". This procedure is a multivariate estimation technique[12] which attempts to uncover long-run stationary relationship(s) among sets of non-stationary data. The approach also allows the user to investigate the speed of adjustment to these long-run equilibria, along with any short-run relationships which may exist. A good guide to the Johansen procedure is contained in Hansen and Juselius (1995), where the maximum likelihood estimation technique is briefly explained. Johansen (1988, 1991) and Johansen and Juselius (1990) give a more elaborate description of the estimation technique. Excellent accounts of the intuition behind the Johansen approach to estimation are contained in Hamilton (1994) and Harris (1995).

Introduction to the Johansen procedure

If z_t is a $p \times 1$ vector of stochastic variables, μ is a constant term and D_t is a vector of nonstochastic variables, such as trend variables, seasonal or intervention dummies, then

[12] The multivariate approach, with its allowance for the potential endogeneity of all the variables of interest, eliminates the single-equation bias which would be problematic for many previous studies in this area.

the Johansen procedure begins by setting out a model in error-correction form[13] as follows, where Δ is the difference operator:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-1} + \mu + \Psi\, D_t + \varepsilon_t, \quad t = 1, \ldots, T. \tag{2}$$

where:

$$\varepsilon_t \sim \text{Niid}_p\,(0, \Sigma) \tag{3}$$

and where k is the lag length. If the data are integrated of order one, hereafter I(1), then the matrix Π has to be of reduced rank, r[14]:

$$\Pi = \alpha\beta' , \tag{4}$$

where α and β are p x r matrices and $r < p$. Under this formulation, therefore, $\beta' z_t$ represents the linear combinations of non-stationary variables which are stationary and α is the matrix of adjustment coefficients. In order to properly interpret the reduced form model, however, it is necessary to impose certain restrictions on the data which are derived from economic theory.

Discussion of the appropriate data set

To proceed with the cointegration analysis we need to define the appropriate information set (Z_t). At a minimum, the chosen vector must be able to shed some light on the key questions concerning the role of wages, the exchange rate and foreign prices in the inflation process. In addition, a central objective of this paper is to provide an assessment of the relevance of the traded/non-traded distinction from the point of view of inflation analysis in a SOE. When choosing which variables to include, it is inevitable that we confront a trade-off between the benefits of model

---

[13] This allows us to distinguish between stationarity due to linear combinations from stationarity due to differencing. It is also an important representation in that it allows us to test a variety of interesting economic hypotheses.

[14] If Π was of full rank, this would imply that all variables were I(0). If Π has zero rank the term Πz_{t-1} drops out of the equation and the variables in question are not cointegrated. If 0 < rank of Π <

parsimony and the potential costs of misspecification due to certain variables being excluded[15]. In light of this consideration, we suggest a five variable vector which includes a measure of the domestic price level (P), a measure of world traded prices (P*), the exchange rate (E), domestic wage costs (W) and a time trend proxy for productivity effects (t):

$$Z_t = \{ P, P^*, E, W, t \} \tag{5}$$

As we shall see, the econometric analysis of this vector can be loosely viewed as testing the long-run validity of i) a wage mark-up model, ii) a pure SOE model or iii) a hybrid model which fuses elements of i) and ii)[16]. A brief explanation of the reasons for allowing for the possibility of a time trend in the cointegration space is warranted. On the basis of economic priors we believed that there should possibly be two long-run cointegrating relationships among the data covered. The first possibility is that of some type of purchasing power parity relationship between domestic prices, foreign prices and the exchange rate. The second is that of a long-run equilibrium relationship between wages and prices. It would, however, be necessary to allow for long run productivity effects in this latter relationship. As a result a time trend was included to proxy for its effect .

The measure of world traded prices employed in this study is a weighted average of the UK and German wholesale price indices. Such a proxy reflects the traditional trade

---

P, there is at least one cointegrating vector. In the absence of I(0) variables, the rank of Π equals the number of stable long-run relationships which exist among the data.

[15] An obvious example of such a trade-off is the choice of whether or not to include money stock variables (foreign and domestic) in Z_t. While we would concur with the idea that foreign monetary aggregates may be highly relevant from the point of view of a SOE, the investigation of alternative international monetary transmission mechanisms is left aside. In this paper, the impact of foreign money is, therefore, assumed to be transmitted *via* the foreign price variable P*.

[16] Callan and Fitzgerald (1989), in a two-step Engle-Granger analysis, consider a similar information set for Irish traded prices. Like us, they propose the vector as a general specification which combines price mark-up elements with long-run purchasing-power-parity. However, Callan and Fitzgerald did not include a time trend to account for the potential impact of productivity. Another significant difference is our use of the Johansen procedure which allows for the possibility of up to *p-1* cointegrating relationships among the *p* variables contained in Z_t. In contrast, the Engle and Granger approach allows for the possibility of only a single cointegrating relation among the variables.

links which exist between Ireland and both the UK and Germany. Wholesale prices are chosen since both the German CPI and the UK RPI are likely to contain sizeable non-traded elements. As in previous studies, e.g. O'Connell and Frain (1989), the nominal effective exchange rate is employed as the relevant exchange rate measure. An index of average weekly earnings in manufacturing is employed as a proxy for economy-wide earnings. Since this proxy for the possible impact of Irish wages on Irish prices is not adjusted for productivity it justifies the inclusion of the time trend[17]. The question of which domestic price measures to employ also needs to be addressed. Given its traditional importance - and central policy significance - a consumer price based measure would seem the most obvious. Accordingly, we choose an underlying measure of aggregate domestic prices which nets out the effects of changes in the mortgage interest sub-index. However, a primary objective of this paper is also to assess the likely relevance of the distinction between traded and non-traded prices. It therefore seems appropriate to analyse separately the determinants of traded and non-traded prices as a precursor to the analysis of aggregate consumer prices. Consequently, an underlying measure of domestic consumer prices has been broken down into its respective traded and non-traded components and each component is analysed independently[18]. Thus, we begin with an analysis of domestic traded prices, and analyse the long-run structure of the vector Z_t^A below, i.e.

$$Z_t^A = \{ P^T, P^*, E, W, t \} \tag{6}$$

where P^T is the traded component of the underlying consumer price series. *A priori*, we might expect a very robust long-run relationship to exist between domestic traded prices, the exchange rate and foreign prices. The Scandinavian model suggests, for example, that in the long run traded prices are determined solely by world traded prices and the exchange rate in a purchasing power parity relationship. In contrast, as implied by the Scandinavian model, the impact of foreign variables on non-traded

[17] For a variety of reasons, the alternative productivity-adjusted measure of wage costs, unit labour costs, was not employed.

prices may be less robust. In fact, in the case of non-traded prices, a wage mark-up model may be more appropriate. In order to assess these possibilities, we also examine the vector Z_t^B below for non-traded price determination:

$$Z_t^B = \{ P^N, P^*, E, W, t \} \tag{7}$$

where P^N is the non-traded component of the underlying consumer price series. Lastly, the determinants of aggregate prices are analysed and assessed in the light of the results for its traded and non-traded components. We conclude, therefore, with the analysis of Z_t^C below:

$$Z_t^C = \{ P, P^*, E, W, t \} \tag{8}$$

A priori, one might expect the long-run structure of aggregate prices to fall somewhere between that of its traded and non-traded components[19].

Results

In our testing procedure, we first confirmed that each of the series under consideration is I(1), thus according with our economic priors. Both the Dickey-Fuller/Augmented Dickey-Fuller and Phillips-Perron tests were used. When deciding upon the appropriate lag length to include in each VAR, the minimum number of lags which is compatible with well-behaved residuals was chosen. This was done on the basis of multivariate Lagrange Multiplier (LM)-type tests for first- and fourth-order autocorrelation and a normality test based on a multivariate version of the univariate Shenton-Bowman test - see Hansen and Juselius (1995) for details. The results of

[18] The construction of price indices for both traded and non-traded sectors is described in full in the Data Appendix, as are the sources of the other variables described above.

these tests are not reported to conserve space; details can, however, be found in Kenny and McGettigan (1996). The number of lags chosen for each combination is presented below in Table 1.

The imposition of the appropriate rank of the Π matrix is one of the most important steps of the Johansen analysis. It is critical because all the subsequent results are conditional on the choice made. If the inferred rank is too small it is likely that true long-run hypotheses will be rejected in error. On the other hand, if the rank is too large, false long-run hypotheses are likely to be accepted too often. Hansen and Juselius (1995) discuss a number of methods of choosing the cointegration rank, three of which we employ. First of all, there are the widely used maximum eigenvalue (λ_{max}) and trace test statistics, the results of which are reported below in Table 1. Secondly, graphical analysis of the estimated cointegration relations can help assess the stability of the hypothesised relationships over time. Finally, the roots of the companion matrix are examined to see how close the largest roots are to the unit circle. In order to conserve space, the latter two techniques are not reported upon in the paper. These tests, however, largely served to confirm our choice of rank in each case.

As can be seen from the table, there is very little ambiguity concerning the choice of model rank. In each case, our *a priori* expectation of a rank of two is strongly supported. The only minor exception to this is for Combination 3, where the Trace test narrowly accepts the hypothesis of rank 1 using the 90% critical values. The λ_{max} test does, however, reject this hypothesis, also using 90% critical values.

Table 1: *l* max and Trace Tests

Combination ¯	**Eigenvalue**	***l* max**	**90% C.V.**	**95% C.V.**	**Trace**	**90% C.V.**	**95% C.V.**	**H_o= r**
	0.5187	42.41**	19.88	31.5	83.79**	58.96	63.0	0
1. P^T, W, E, P*, t	0.3366	23.80*	16.13	25.5	41.38*	39.08	42.4	1
(5 Lags)	0.1678	10.65	12.39	19.0	17.58	22.95	25.3	2

[19] The cointegration analysis is applied to each of the vectors (6), (7) and (8) over the sample period 1979:Q1 to 1995:Q3.

	0.1125	6.92	10.56	12.3	6.92	10.56	12.3	3
2. P^N, W, E, P*, t (2 Lags)	0.6791 0.4096 0.1754 0.0956	69.33** 32.14** 11.76 6.13	19.88 16.13 12.39 10.56	31.5 25.5 19.0 12.3	119.37** 50.03** 17.89 6.13	58.96 39.08 22.95 10.56	63.0 42.4 25.3 12.3	0 1 2 3
3. P, W, E, P*, t (5 Lags)	0.5040 0.2892 0.1536 0.1144	40.67** 19.80* 9.68 7.05	19.88 16.13 12.39 10.56	31.5 25.5 19.0 12.3	77.19** 36.52 16.72 7.05	58.96 39.08 22.95 10.56	63.0 42.4 25.3 12.3	0 1 2 3

* H_o rejected at the 10% level
** H_o rejected at the 5% level

Long-run identification

Although at this stage it is possible to arrive at estimates of the two stationary β cointegrating vectors after imposing the chosen rank of 2, such vectors are not necessarily meaningful or interesting. The reason for this is that any linear combination of the stationary vectors is also a stationary vector. This is, of course, the classic identification problem, which must be overcome if we are to reach meaningful conclusions. Johansen and Juselius (1992, 1994) provide a thorough description of the identification issue. The first stage in the procedure is to ensure that the model is generically identified from a long-run perspective. In essence, generic identification of the long-run structure entails imposing restrictions on the space occupied by β such that each cointegrating relation is <u>unique</u>. For a unique identification, it is necessary to impose at least *p(p-1)* restrictions on the short-run structural form parameters. The long-run parameters are the same in both the reduced and structural forms, however, implying that long-run identification can precede short-run identification.

Johansen and Juselius (1994) develop a rank condition which must be satisfied in order for a model to be generically identified, making use of a set of R_i and H_i matrices associated with the long-run structural hypotheses. R_i are defined as p x k_i matrices of full rank, and $H_i = R_{i\perp}$ are defined as p x s_i (where $k_i + s_i = p$) matrices, such that H_i are of full rank and satisfy $R'_i H_i = 0$. There are, accordingly, k_i restrictions and s_i parameters to be estimated for each *i*th relationship. Each of the cointegrating relations is assumed to satisfy the restrictions $R'_i \beta_i = 0$, or, equivalently, $\beta_i = H_i\varphi_i$ for each relation, where φ_i are each of the form of a s_i vector. In our case the β matrix is a 5 x 2 matrix, and $\beta = (H_1 \varphi_1, H_2 \varphi_2)$. The generalised rank conditions are set out in

Theorem 1 of Johansen and Juselius (1994) (p. 15). For our purposes, given that we have accepted a rank of 2, the rank conditions are as follows:

$$r_{i,j} = rank(R_i^{'} H_j) \geq 1, i \neq j. \qquad (9)$$

The generic rank conditions were tested for the various hypothesis combinations and the results are presented in table 2 below. Such hypotheses start off in row A with the

Table 2: Verification of the rank condition of generic identification in the long-run structure

		Hypothesis	Rank ($R'_1 H_2$)	Rank ($R'_2 H_1$)	Satisfaction of generic identification
A	Hyp 1	P, E, P* stationary; W, t = 0	2	2	√
	Hyp 2	W, P, t stationary; E, P* = 0			
B	Hyp 1	P, E, P* stationary; W, t = 0	2	3	√
	Hyp 2	W = P, t stationary; E, P* = 0			
C	Hyp 1	P= -q E + q P* stationary; W, t = 0	2	1	√
	Hyp 2	W, P, t stationary; E, P* = 0			
D	Hyp 1	P = -q E + q P* stationary; W, t =0	2	2	√
	Hyp 2	W = P, t stationary; E, P* = 0			
E	Hyp 1	P= -E + P* stationary; W, t = 0	3	1	√
	Hyp 2	W, P, t stationary; E, P* = 0			
F	Hyp 1	P = -E + P* stationary; W, t = 0	2	1	√
	Hyp 2	W = P, t stationary; E, P* = 0			

relatively weak conditions that (1) some combination of P, E and P* be stationary and (2) some combination of W,P and t be stationary. They proceed to the strongest set of restrictions in row F which hypothesises (1) full PPP and (2) wages equalling prices plus some trend growth to account for productivity changes. From the table, it is clear that, for all the hypothesis combinations outlined, the generic rank conditions are satisfied.

The results of the long-run hypothesis tests, which were shown to be generically identifying in the previous table, are contained in Tables 3(a) to 3(c) below and make for some very interesting reading. As Johansen and Juselius (1992, 1994) argue, the types of hypotheses tested for below give rise to a likelihood ratio test that is asymptotically distributed as χ^2. These tests can be used to check for non-rejection of the restrictions imposed. In Table 3(a), there is evidence of a long-run purchasing power parity relationship between domestic traded prices, the exchange rate and the measure of world traded prices[20]. This relationship is consistent with the SOE model of domestic *traded* price determination. For non-traded prices (Table 3(b)), the strict version of purchasing power parity was completely rejected. Instead, a weaker stationary relationship was identified with correctly signed and economically meaningful coefficients[21]. The results for aggregate prices, perhaps not surprisingly, fall somewhere in between those for its traded and non-traded components. The strict version of PPP is almost acceptable (P-value = 0.04) and a stationary relationship with the exchange rate and the foreign price level with sensible coefficients was also identified with a high probability value. In addition, the cointegration analysis has uncovered a trend stationary real wage. This is so whether the real wage is measured in terms of its purchasing power over traded or aggregate consumer prices[22]. Furthermore, it can be remarked that the long-run coefficients reported in the right hand columns of each Table are correctly signed and are, for the most part, very

[20] A negative sign on the exchange rate, E, is hypothesised in each of the PPP relationships because the way in which E is measured means that an increase in its value is associated with an appreciation.

[21] Froot and Rogoff (1995) have commented on the fact that PPP coefficients obtained from the various international studies they surveyed varied enormously and were often implausible.

[22] It is important to note that the stationary relationship between P^N, W and t cannot be interpreted as a real wage measured in terms of its purchasing power over non-traded prices. This is due to the fact that there is not a coefficient of unity on the level of non-traded prices and, hence, the nominal wage is not deflated by the full increase in non-traded prices.

Table 3(a): Traded Prices:Long-run hypothesis test results= (P^T, W, E, P*, t)					
Test		**Hypotheses**	**Test Results**	**Significance**	**Estimated long-run relationship**
1a	Hyp 1	P^T, E, P*	$c^2(2) = 0.87$	**	$P^T = -0.405 E + 0.921 P^*$
	Hyp 2	W, P^T, t	P-Value = 0.65		$W = 1.203 P^T + 0.004 t$
2a	Hyp 1	P^T, E, P*	$c^2(3) = 1.40$	**	$P^T = -0.490 E + 0.969 P^*$
	Hyp 2	$W = P^T + a t$	P-value = 0.71		$W = P^T + 0.005 t$
3a	Hyp 1	$P^T = -q E + q P^*$	$c^2(3) = 6.59$	*	$P^T = -0.638 E + 0.638 P^*$
	Hyp 2	W, P^T, t	P-value = 0.09		$W = 1.170 P^T + 0.006 t$
4a	Hyp 1	$P^T = -q E + q P^*$	$c^2(4) = 6.76$	**	$P^T = -0.753 E + 0.753 P^*$
	Hyp 2	$W = P^T + a t$	P-value = 0.15		$W = P^T + 0.006 t$
5a	Hyp 1	$P^T = -E + P^*$	$c^2(4) = 9.21$	*	$P^T = -E + P^*$
	Hyp 2	W, P^T, t	P-value = 0.06		$W = 0.885 P^T + 0.005 t$
6a	Hyp 1	$P^T = -E + P^*$	$c^2(5) = 9.58$	*	$P^T = -E + P^*$
	Hyp 2	$W = P^T + a t$	P-value = 0.09		$W = P^T + 0.005 t$

** Joint hypothesis acceptable with a probability value above 0.10
* Joint hypothesis acceptable with a probability value above 0.05
† Joint hypothesis acceptable with a probability value above 0.01

Table 3(b): Non-traded prices, Long-run hypothesis test results: (P^N, W, E, P*, t)					
Test		**Hypothesis**	**Test Results**	**Significance**	**Estimated long-run relationship**
1b	Hyp 1	P^N, E, P*	$c^2(2) = 0.52$	**	$P^N = -0.308 E + 1.242 P^*$
	Hyp 2	W, P^N, t	P-Value = 0.77		$W = 0.518 P^N + 0.006 t$
2b	Hyp 1	P^N, E, P*	$c^2(3) = 17.27$		Not Applicable
	Hyp 2	$W = P^N + a t$	P-Value = 0.00		Not Applicable
3b	Hyp 1	$P^N = -q E + q P^*$	$c^2(3) = 16.73$		Not Applicable
	Hyp 2	W, P^N, t	P-Value = 0.00		Not Applicable
4b	Hyp 1	$P^N = -q E + q P^*$	$c^2(4) = 28.68$		Not Applicable
	Hyp 2	$W = P^N + a t$	P-Value = 0.00		Not Applicable
5b	Hyp 1	$P^N = -E + P^*$	$c^2(4) = 21.67$		Not Applicable
	Hyp 2	W, P^N, t	P-Value = 0.00		Not Applicable
6b	Hyp 1	$P^N = -E + P^*$	$c^2(5) = 30.52$		Not Applicable
	Hyp 2	$W = P^N + a t$	P-Value = 0.00		Not Applicable

** Joint hypothesis acceptable with a probability value above 0.10
* Joint hypothesis acceptable with a probability value above 0.05
† Joint hypothesis acceptable with a probability value above 0.01

Table 3(c): Overall prices:Long-run hypothesis test results = (P, W, E, P*, t)					
Test		**Hypothesis**	**Test Results**	**Significance**	**Estimated long-run relationship**
1c	Hyp 1	P, E, P*	$\chi^2(2) = 1.77$	**	P = -0.357E + 1.080P*
	Hyp 2	W, P, t	P-Value = 0.41		W = 1.352P + 0.001 t
2c	Hyp 1	P, E, P*	$\chi^2(3) = 2.54$	**	P = -0.432E + 1.113P*
	Hyp 2	$W = P + \alpha t$	P-Value = 0.47		W = P + 0.003 t
3c	Hyp 1	$P = -\theta E + \theta P^*$	$\chi^2(3) = 6.40$	*	P = -1.506E + 1.506P*
	Hyp 2	W, P, t	P-Value = 0.09		W = 0.390P + 0.007 t
4c	Hyp 1	$P = -\theta E + \theta P^*$	$\chi^2(4) = 10.82$	†	P = -0.760E + 0.760P*
	Hyp 2	$W = P + \alpha t$	P-Value = 0.03		W = P + 0.006 t
5c	Hyp 1	P = -E + P*	$\chi^2(4) = 11.85$	†	P = -E + P*
	Hyp 2	W, P, t	P-Value = 0.02		W = 0.928P + 0.005 t
6c	Hyp 1	P = -E + P*	$\chi^2(5) = 11.90$	†	P = -E + P*
	Hyp 2	$W = P + \alpha t$	P-Value = 0.04		W = P + 0.005 t

** Joint hypothesis acceptable with a probability value above 0.10
* Joint hypothesis acceptable with a probability value above 0.05
† Joint hypothesis acceptable with a probability value above 0.01

sensible. Given the short sample period considered, it is, perhaps, surprising that any support was found for PPP using our dataset. Nevertheless, there has been a fair degree of backing for PPP in previous Irish studies, in spite of this shortcoming. Leddin (1988) is alone in unambiguously rejecting PPP. Thom (1989), Callan and Fitzgerald (1989) Wright (1993, 1994) and Leddin and Hodnett (1995) all lend varying degrees of support to the proposition.

As has been argued above, the analysis in this paper can be largely viewed as testing the validity of i) a pure wage mark-up model ii) a pure SOE model or iii) a hybrid model fusing elements of i) and ii). At this stage, it is imperative to point out that, despite the interesting nature of the cointegration results given above, the consistency (or otherwise) of the data with either of these models of price determination requires some knowledge of how each of the variables reacts given a disturbance which pushes the system away from equilibrium. For example, if it was found that the PPP relationship was enough to determine the adjustment of each of the variables in the system then this would constitute evidence in support of the pure SOE model. On the other hand, if the real wage relationship was all that was needed to explain the adjustment of the system back into equilibrium, then this would be suggestive of a strong role for wages in accord with the wage mark-up model. Lastly, if *both* long-run relationships simultaneously explain the adjustment of the system following a disturbance from equilibrium, then this would constitute evidence in favour of a hybrid model. It is to an analysis of these important dynamic issues that we now turn.

Short-run Dynamics

Johansen and Juselius (1994) highlight the problems associated with drawing conclusions about economic structure from the estimated reduced form. In particular, they point to the overparameterisation of the VAR structure. As a result, several of the parameters, including the highly relevant parameters in the adjustment matrix (α), may be inefficiently estimated. Furthermore, a structural economic model would have to identify any possible simultaneous effects between the variables of the system. This is of particular importance in the context of wage-price dynamics which many economists believe to be determined simultaneously. The short-run identification approach used here loosely follows that of Johansen and Juselius (1994). To move to a more parsimonious model we re-estimate each system of equations using the restricted (identified) cointegrating vectors uncovered in the previous section. In all cases, we condition on the world traded price variable[23]. This allows us estimate a three equation system for wages, prices and the exchange rate conditional on the long-run structures identified in the previous section[24]. Standard conditional inference techniques are employed in reducing the parameterisation of the model: variables are dropped from the system if they are not significant and if their removal does not generate undesirable properties in the residuals (autocorrelation problems etc.)[25].

Traded Prices

---

[23] The system was estimated conditional on foreign traded prices, P*, given that endogenising such a variable on domestic factors would not be sensible. Only if a variable has been found to be weakly exogenous is one strictly justified in conditioning on it in formulating a structural economic model. The fact that P* was not in general found to be weakly exogenous points toward the exclusion of a potentially relevant variable, e.g. foreign money, from our system. The investigation of a role for foreign money is, however, left for future research.

[24] As will be seen shortly, we condition on both foreign prices and the exchange rate in the non-traded price system. The reason for doing this is the implausible parameters obtained in the exchange rate equation in this system. Our analysis of non-traded prices is, accordingly, incomplete as will be explained in more detail below.

[25] The estimation and system reduction is carried out using full information maximum likelihood estimation in the PcFiml package. See Doornik and Hendry (1994).

Table 4 below reports parameter values for the short-run conditional wage/traded price/exchange rate system. Also reported in the table are diagnostic statistics for residual autocorrelation and normality[26]. The equations are estimated conditional on the long-run PPP relationship (ECM^1) and also the trend stationary real wage (ECM^2). Several features of the table warrant commentary. Firstly, in the equation for traded prices, the adjustment coefficient to the long-run PPP relation (ECM^1) implies significant adjustment at approximately 9.7% per quarter. Since this is the strict version of PPP, it implies complete long-run pass-through from any change in the exchange rate or world traded prices into domestic traded prices. If all of the adjustment back to equilibrium is effected through traded prices themselves, this implies a half life of deviations away from PPP of approximately 6.8 quarters[27]. It is also interesting to note that the cointegrating real wage relation enters significantly into the equation for traded prices with a positive sign[28]. The positive coefficient implies that any increase in real wages greater than that which is warranted by productivity growth feeds through to traded price inflation. This finding suggests that there is a long-run role for wages in determining prices even in the traded sector. Accordingly, the results are not consistent with the predictions of the Scandinavian model for traded price inflation in which unidirectional causation, running from prices

[26] See Doornik and Hendry (1994), Chapter 10, for a description of these test statistics and for further references.

[27] As will be made clear below, both wages and the exchange rate also adjust to restore the system to its PPP equilibrium. This has the potential to speed up the adjustment process following, for example, a shock to the exchange rate. Exactly how fast the system adjusts back to equilibrium following a shock to either wages, prices or the exchange rate is examined in the impulse response analysis below.

[28] If the equilibrium real wage was normalised on traded prices the adjustment coefficient would, of course, be negative indicating that traded prices adjust downward if they are above their equilibrium level.

Table 4: Conditional Wage-Price-Exchange Rate System: Traded Prices

	Con.	DP^T_{t-3}	DW_t	DW_{t-3}	DW_{t-4}	DE_{t-4}	DP^*_{t-1}	DP^*_{t-2}		ECM^1_{t-}
DP^T_t	**0.475** (4.16)	**0.376** (4.13)	-	-	-	**0.110** (1.86)	**0.777** (3.49)	**-0.487** (-2.35)		**-0.097** (-3.89
	Con.		DW_{t-1}			DE_t	DE_{t-4}		-	ECM^1_{t-}
DW_t	**0.838** (7.31)	-	**-0.310** (-2.92)	-	-	**-0.191** (-2.15)	**0.268** (3.76)	-	-	**-0.184** (-7.39
	Con.	DP^T_{t-4}	DW_t	DW_{t-3}	DW_{t-4}	DE_{t-1}	DP^*_{t-1}	DP^*_{t-3}	DP^*_{t-4}	ECM^1_{t-}
DE_t	**1.29** (4.52)	**-0.520** (-3.39)	**-0.732** (-2.58)	**-0.331** (-2.92)	**-0.394** (2.95)	**0.526** (4.77)	**1.029** (2.99)	**-1.821** (-4.70)	**0.991** (2.78)	**-0.288** (-4.61

ECM^1: [P^T + E - P*] Vector AR(1 - 4) :

ECM^2: [W - P^T - 0.005 t] Vector Normality:

N.B. Centered seasonal dummies are included in each of the equations of the above system. Co-efficient estimates are not reported in order to conserve space.

to wages is posited[29]. The results are more consistent with a "hybrid model" where, although there is complete PPP, wages can still influence the domestic rate of traded price inflation because the exchange rate is no longer fixed[30]. This evidence on the hybrid model implies that outcomes in both the goods and foreign exchange markets (captured by the ECM^1 term) as well as in the labour market (captured by ECM^2) together determine the inflation rate for traded prices in an SOE. Recently, Dennis(1995) has argued that the assumption that only a single error correction term enters the equation for a particular variable is too restrictive since it implies that any market disequilibrium affects only one market directly. The above findings on the hybrid model can be viewed as providing evidence in support of the contention that several disequilibria can affect the inflation rate directly.

Turning next to the wage equation in Table 4, the adjustment of nominal wages to the strict PPP relation, at 18.4% per quarter, is even more rapid than the adjustment of traded prices. This finding suggests that an overvalued real exchange rate has a deflationary impact on Irish wages: it could, for example result in higher unemployment which would exert downward pressure on wages. The negative co-efficient on ECM^2 in the wage equation implies that if wages happen to exceed their warranted long-run equilibrium with traded prices they will also adjust downwards. The important role of both ECMs highlights the long-run endogeneity of wages with respect to both foreign (P*) and domestic (E, P^T) variables. Accordingly, this finding constitutes a strong rejection of the hypothesis that wages could ever be viewed as a long-run *exogenous* cost-push factor. It is interesting to ask what type of wage-bargaining behaviour is implied by these findings. The significance of ECM^2 in the wage equation suggests that wage negotiators, in staking their wage claims, take into account any changes in the level of domestic traded prices and productivity. However,

---

[29] A finding that traded prices were weakly exogenous with respect to wages, i.e. that ECM^2 did not enter significantly into the equation for traded prices, would be more consistent with both the Scadinavian model or the simple SOE view of traded price determination. These observations are, however, subject to the qualification that the ECM^2_{t-1} in Table 4 is not a "true" equilibrium real wage, since it is expressed only in terms of its purchasing power over traded prices.

[30] Some readers may view the finding that both ECMs enter the equation for traded price inflation to be contradictory. However, the positive effect of wages on prices is consistent with the observed PPP equilibrium given the persistent changes in the nominal exchange rate which have taken place over the sample period.

given Ireland's SOE status, it is also not surprising that the overall "competitiveness" of the economy, as measured by the real exchange rate term (ECM^1) also affects the outcome of wage negotiations.

The coefficients on the ECMs in the exchange rate equation also accord well with economic intuition. As might be expected in a small open economy, the purchasing power parity equilibrium appears to explain a large part of the movement in the nominal effective exchange rate. Deviations from the PPP equilibrium are closed via reasonably swift adjustment of the exchange rate. The estimated coefficient on the ECM^1 term of - 0.288 implies (assuming only the exchange rate is adjusting) a half life of deviations from PPP of just over 2 quarters. Compared with the slower adjustment of traded prices themselves (half life of 6.7 quarters noted above), this constitutes empirical evidence in support of the standard assumption in economics that asset market adjustment is significantly quicker than goods market adjustment[31]. Turning lastly to the coefficient on the equilibrium real wage (ECM^2), consistent with previous evidence on the "hybrid model", excessive wage pressure has a negative (depreciating) effect on the exchange rate. Given the systematic nature of the relationships among each of the endogenous variables in the system, such excessive wage growth will in turn be reflected in a rise in domestic traded prices.

Economic theory has less to say concerning the coefficients on the short-run variables in each equation. In the traded price equation, however, the positive sign on the coefficient for ΔP^T_{t-3} is possibly indicative of some short-run persistence in traded price inflation. Alternatively, it could be proxying for inflation expectations in a manner consistent with an adaptive expectations/distributed lag specification. Furthermore, it can be seen that the net short-run effect of a change in foreign prices is positive. The positive sign on the coefficient for ΔE_{t-4} is more difficult to interpret but is not quite significant at the 5% level (it is, nevertheless, retained in the system to preserve well-behaved residuals). Finally, none of the lags of wages are statistically significant. In contrast, in the exchange rate equation there is a strong negative impact of lagged changes in wages. The short-run coefficients in the wage equation are not, however, readily interpretable. Any further interpretation of these short run coefficients is left up to the reader[32].

The dynamic interactions among prices, wages and the exchange rate in the above system can be more clearly seen by making use of a set of impulse response functions[33]. The responses of each of these three variables to various shocks are reported in Figures A.1 to A.3 of Appendix A. Firstly, it should be noted that in the case of all three sets of simulations the long run relationships implied by the ECM's, i.e. an equilibrium real wage and a PPP relationship, are preserved after the system has adjusted to the shocks. It can also be seen that, consistent with the non-stationarity in the data, shocks to the variables have permanent effects. Figure 1A demonstrates that prices and wages are permanently affected by roughly half of the size of the original shock. Following a shock to prices (Figure A1), it takes roughly four years for wages to move back into equilibrium. In contrast, the exchange rate initially overshoots but subsequently returns to its warranted long-run level (implied by the PPP equilibrium condition) after about 12 quarters. In the case of a wage shock (Figure A.2), it can be seen how it also takes roughly four years for prices to move back into line with wages, although in this case the exchange rate takes the same amount of time to reach its equilibrium PPP level. In contrast to the case of a shock to prices, the system takes a lot longer to settle and the shock to wages ends up being amplified somewhat over time[34]. Finally, when the exchange rate is shocked (Figure A.3), prices and wages move fairly quickly into line with one another, but take a considerable length of time to settle at their new "equilibrium" levels. In addition, in this case, close to full PPP equilibrium is restored after about 16 quarters.

Non-Traded Prices

---

[31] The exchange rate overshooting literature, originating with Dornbusch (1976), relies on the assumption that exchange rate and asset markets adjust relatively quicker than goods markets.

[32] It is perhaps important to point out that the long-run behaviour of the system, e.g. the long-run response of prices to the exchange rate, is completely independent of these short run coefficients.

[33] We reparameterise the VECM presented in Table 4 in levels in order to perform the impulse response analysis. The results given above assume that the ordering of the variables for the purposes of the Choleski decomposition of the residuals is as follows: traded prices, wages and the exchange rate.

[34] This finding is consistent with the possibility of a wage-price spiral being initiated by a shock to wages.

Table 5 below reports parameter values and estimated t-statistics for a short-run conditional wage and non-traded price system. We have conditioned upon the exchange rate as the sign of the trend stationary real wage term (ECM^2) was positive in the exchange rate equation, instead of being negative as expected. Since the coefficient on P^N is not unity, however, this relationship cannot be readily interpreted as a real wage measured in terms of its purchasing power over non-traded prices and this may be responsible for such an unusual result. The two equation system is estimated conditional on the two long-run vectors that could be identified for non-traded prices (See Table 3(b)). The first of these (ECM^1) describes a stationary relationship between the level of non-traded prices, the level of world traded prices and the nominal effective exchange rate. This is a significantly weaker relationship than the strict version of PPP identified in the analysis of traded prices. The second relevant long-run structure (ECM^2) has already been described above[35].

Both the non-traded price and wage equations appear reasonably intuitive. The significance of ECM^1 in the equation for non-traded prices implies a strong long-run effect of both the exchange rate and world traded prices on non-traded prices. Adjustment to this equilibrium takes place at approximately 23% per quarter, implying a half life of deviations from equilibrium of 2.7 quarters. It should be remembered, however, that this is a weaker relationship than the strict version of PPP identified for traded prices. Accordingly, in contrast to the equation for traded prices, the estimated equation for non-traded prices does not provide empirical evidence of complete 100% pass-through from any change in the exchange rate and/or world traded prices. In addition, the wage-non-traded price cointegrating relation enters significantly into the equation for non-traded prices with a positive sign.

[35] When the data series were originally examined, there appeared to be marked seasonality in the non-traded price series. This may be partly responsible for the fact that only the weakest joint hypotheses were found to be acceptable in Table 3(b) for the non-traded price system. The possibility of seasonal cointegration was left aside in this paper.

Table 5: Short-run Conditional Wage-Price System: Non-Traded Prices

	Con.	$D\mathbf{P}^N_{t-1}$	$D\mathbf{E}$	$D\mathbf{E}_{t-1}$	$\mathbf{ECM}^1_{t-1}$	$\mathbf{ECM}^2_{t-1}$
$D\mathbf{P}^N_t$	**-0.393** **(-4.11)**	**0.189** **(2.27)**	**-0.112** **(-2.66)**	**0.089** **(2.24)**	**-0.228** **(-8.80)**	**0.246** **(4.60)**
	Con.	$D\mathbf{P}^N_{t-1}$	$D\mathbf{W}_{t-1}$	$D\mathbf{E}_{t-1}$	$\mathbf{ECM}^1_{t-1}$	$\mathbf{ECM}^2_{t-1}$
$D\mathbf{W}_t$	**0.716** **(8.77)**	**-0.466** **(-3.07)**	**-0.379** **(-3.84)**	**-0.159** **(-2.21)**	**-**	**-0.362** **(-8.63)**

ECM^1: [P^N + 0.308 E - 1.242 P*] Vector AR(1 - 4) : F(16, 80) = 0.9686[0.4974]

ECM^2: [W - 0.518 P^N - 0.006 t] Vector Normality: $\chi^2(4)$ = 10.691[0.030]

The wage equation in Table 5 is comparable with the equivalent equation from Table 4[36]. However, in this instance, the second error correction term dominates in terms of explanatory power. Surprisingly, the stationary equilibrium between P^N, P* and E can be deleted from the wage equation[37]. Adjustment to the real wage relation takes place at a very rapid pace of about 36% per quarter. In other words, movements of the real wage away from its warranted long-run value, whether arising from wage or price movements, will give rise to the appropriate nominal wage adjustment.

As explained above for traded prices, theory has less to say concerning the coefficients on the short-run variables in each equation. It can be observed that short-run wage effects are not significant in the price equation and, consequently, they can be excluded from the equation for ΔP^N without generating residual autocorrelation[38]. The other short-run parameters in the equation for ΔP^N are signed in a manner consistent with economic priors: a net positive impact from the lagged dependent variable (signifying persistence in non-traded inflation), and a net negative impact from current and lagged

[36] The dependent variable is, for example, the same in each case. The equations differ insofar as in Table 5 lagged changes in non-traded prices (as opposed to traded) are employed as explanatory variables. As we have already described, the ECMs also differ significantly.
[37] When ECM^1_{t-1} is included in the wage equation, it is wrongly signed and insignificant, with a t-statistic of 0.227.
[38] There is some evidence of non-normal residuals in the conditional system, however. Taken together with the previous observation that the coefficient on ECM^2 in the exchange rate equation produced nonsensical results, this suggests a large degree of misspecification (e.g. missing variables) in the

changes in the EER. Perhaps not surprisingly in the case of non-traded prices short-run movements in world traded prices are not significant. As regards the wage equation, the coefficients on the lagged short-run variables are not - apart from the significant negative impact of the lagged exchange rate- intuitively interpretable.

Impulse response analysis (not reported), was performed using a three equation system (i.e. including an exchange rate equation) and, subsequently, for the two equation system given above[39]. In the case of the three equation system, a positive shock to wages gives the implausible result that the exchange rate ends up appreciating and prices and wages end up being lower than their initial pre-shock values! This strange outcome is driven by the positive sign on the ECM^2 in the exchange rate equation, which implies that excessive wage pressure leads to exchange rate appreciation. For the two equation system, shocks to both non-traded prices and wages die out over time. This makes sense, given that conditioning on the exchange rate for the purposes of impulse response analysis is equivalent to assuming that the authorities are pursuing a non-accomodating fixed exchange rate monetary policy. Since foreign prices are also assumed to be fixed, domestic price variables gradually revert to their pre-shock levels, given the need to adhere to a type of PPP relationship in the long run[40].

Aggregate Prices

The identification of a wage-price-exchange rate system for the underlying CPI series is perhaps of most interest from a policy viewpoint. Table 6 below reports parameter values and t-statistics from a wage-price-exchange rate system conditional on the long-run relations identified under test 6c of Table 3(c). These are equivalent to a) a stationary real exchange rate (ECM^1) with unitary coefficients on E and P* and b) a trend stationary real wage (ECM^2). The PPP relationship implied in ECM^1 was not strictly acceptable at the normal levels of significance (i.e. it had a p-value of 0.04). It was, however, found to be highly significant in all three equations when estimated as

---

vector for non-traded prices. Accordingly, further econometric analysis of the determinants of non-traded prices is certainly warranted.

[39] These response functions are available from the authors upon request.

[40] Although the so-called PPP equilibrium relationship in the non-traded sector does not conform with the requirements of unity on the exchange rate and foreign price variables, in the impulse response functions it serves the purpose of anchoring the domestic price level to the foreign price level in the absence of changes to the exchange rate.

part of the parsimonious (PVAR) system, thereby providing indirect evidence of its validity as a long-run cointegrating relationship. The system was, therefore, estimated conditional on the full PPP ECM^1, rather than the weaker forms of PPP relationships uncovered in the previous section. The real wage relation also has a more specific interpretation in this instance. Arguably, it is only in this case that the ECM^2 term can be considered a representative measure of the real wage. This is because here it is measured in terms of its purchasing power over an index of the cost of living (i.e. aggregate consumer prices)[41].

In line with the preceding results for traded prices, there appears to be strong evidence of bi-directional feedback between wages and prices. In the equation for aggregate consumer price inflation, as would be expected, the estimated coefficient on the equilibrium PPP relationship is smaller than in the equivalent traded price equation. It is, nonetheless, highly significant and implies a half life of deviations from PPP of over ten quarters (assuming that only prices themselves adjust). The adjustment coefficient to the ECM^2 term describes the strength of direct feedback from wages to prices at an aggregate level. Further evidence in favour of the argument that the direction of causation between wages and prices is bi-directional is provided by the significance of the stationary PPP relationship in the equation for ΔW. This implies, for example, that an overvalued real exchange rate will have a deflationary impact on wages, with adjustment of wages estimated to take place at approximately 10.8% per quarter - somewhat slower than for traded prices. Somewhat surprisingly, however,

[41] The real wage measure contained in the traded price system can, however, be considered as a reasonable approximation to a representative real wage, given its weighting of over 70 per cent. of the CPI.

Table 6: Conditional Wage-Price-Exchange Rate System: Aggregate Prices

	Con.	ΔP_{t-1}	ΔP_{t-3}		ΔE_{t-1}	ΔP^*_{t-1}				ECM
ΔP_t	**0.341** **(3.34)**	**-0.241** **(-2.52)**	**0.337** **(3.72)**		**-0.078** **(-1.68)**	**0.571** **(3.56)**				**-0.06** **(-3.03**
	Con.	ΔP_{t-2}	ΔW_{t-1}			ΔE_{t-4}			ΔP^*_{t-2}	**ECM**
ΔW_t	**0.512** **(3.62)**	**0.564** **(4.41)**	**-0.307** **(-3.02)**			**0.303** **(4.79)**			**-0.552** **(-2.63)**	**-0.10** **(-3.56**
	Con.	ΔP_{t-4}	ΔW_{t-3}	ΔW_{t-4}	ΔE_{t-1}	ΔE_{t-4}	ΔP^*_{t-1}	ΔP^*_{t-3}	ΔP^*_{t-4}	**ECM**
ΔE_t	**0.922** **(3.58)**	**-0.679** **(-3.72)**	**-0.468** **(-2.96)**	**-0.530** **(-3.41)**	**0.544** **(5.02)**	**-0.249** **(-2.35)**	**0.634** **(1.73)**	**-1.85** **(-4.73)**	**1.445** **(3.74)**	**-0.19** **(-3.56**

ECM^1: [P + E - P*]   Vector AR(1 - 4): F(36,95

ECM^2: [W - P - 0.005 t]   Vector Normality: χ^2 (

N.B. Centered seasonal dummies are included in each of the equations of the above system. Co-efficient estimates are not reported in order to conserve space.

wages do not adjust directly to the trend stationary real wage relationship, given that the ECM^2 term in the wage equation was found to be statistically insignificant. The real wage ECM^2 also falls out of the exchange rate equation, although the PPP relationship is, once again, highly significant, with the expected negative sign (implying that an overvalued real exchange rate leads to a weakening of the nominal exchange rate).

The short-run coefficients in the aggregate price equation appear to be correctly signed and accord with economic intuition: there is a net positive impact of lagged changes in prices, a net negative impact of a change in the EER and a significant net positive impact of lagged changes in world traded prices. Similarly, the short-run coefficients in the exchange rate equation all make sense implying persistence in the exchange rate, and a negative relationship with respect to domestic price and wage pressures and a net positive effect with respect to foreign price developments. Only the price variable enters the wage equation with the expected sign, however.

Finally, the results from the impulse response analysis from the aggregate price system are broadly similar to that of the traded price system. However, the response to a price shock (Figures A.4) shows that full adjustment is somewhat slower taking roughly 5 years in the case of adjustment to PPP and almost 6 years for the real wage equilibrium to be reached. Similarly, in response to a wage shock, the system evolves such that an initial shock to wages is amplified within the system and, once again, adjustment takes longer than is the case for traded prices. Lastly, the exchange rate shock generates similar impulse responses to that in the traded price system. Overall, as before, the system responds so that in the long run the real wage and PPP equilibria are maintained.

4. Summary and Conclusions

This paper has attempted to model the price determination process in a small open economy using multivariate cointegration analysis and impulse response functions. The data-based modelling approach which was employed could be loosely viewed as testing the long-run validity of i) a pure wage mark-up model, ii) a pure price-taking small open economy model or iii) a hybrid model which fuses elements of i) and ii). The analysis, which covers the period 1979:Q1 - 1995Q3, has served to clarify important issues in regard to the validity of a distinction between traded and non-traded prices, the determinants of aggregate consumer price inflation and also the role of wages and the exchange rate in the inflation process. It is hoped, therefore, that the paper serves to add to current understanding of the Irish inflationary process which, it is claimed, has been a topic of considerable controversy since the break with sterling.

Central to the empirical approach adopted in this study was the consideration of potentially separate price determination processes for the traded and non-traded sectors. In the case of traded prices, the strongest form of the PPP relationship was shown to be consistent with the data. The estimated adjustment coefficients, together with the associated impulse response functions, demonstrated that full pass-through from a change in the nominal exchange rate to domestic traded prices (and wages) takes roughly 3 or 4 years. By contrast, in the case of non-traded prices, the data strongly reject the strict long-run purchasing power parity paradigm. Nonetheless, non-traded prices were shown to cointegrate with both world traded prices and the exchange rate. This equilibrium was shown to be highly significant in an equation for non-traded inflation, thus confirming the strong role played by both the exchange rate and foreign prices even in the non-traded sector. The overall results for the non-traded sector are, however, far from satisfactory, given the poor behaviour of the exchange rate equation and the non-normal residuals in the system. Perhaps the augmentation of the non-traded price system with some additional domestic variables is a worthwhile avenue for future research. As would be expected, the results for aggregate prices fall somewhere between those for its traded and non-traded components. A stationary combination of the domestic consumer prices, world traded prices and the nominal exchange rate was strongly accepted by the data, while the strict version of PPP was only tentatively accepted. Adjustment of aggregate prices to shocks in the exchange rate is, as expected, somewhat slower than is the case for traded prices.

Taken together, the results highlight the need to distinguish between traded and non-traded sectors in the analysis of inflation in a small open economy. Statistically significant differences which exist between traded and non-traded price determination are lost when inflation is analysed only in terms of the aggregate consumer price index. Finally, the paper demonstrated that strong bi-directional causality exists between prices and wages for all three sets of prices examined. Hence, talk of wage pressure as being an exogenous source of Irish inflation is misplaced.

References

Aukrust, D. (1977): "Inflation in the open economy: A Norwegian model" in L. B. Krause and W. S. Salant (eds.), Worldwide Inflation, (Washington D.C.: Brookings Institution)

Bradley J. (1977): "Lags in the transmission of inflation", *The Economic and Social Review*, Vol. 8, No. 2, pp. 149-154.

Browne, F.X. (1982): "Modelling export prices and quantities in a small open economy", *The Review of Economics and Statistics,* Vol. LXIV, No. 2, pp. 346-347.

Browne F.X. (1983): "Price setting behaviour for traded goods - the Irish case", *Applied Economics*, Vol. 15, pp. 153-163.

Browne, F. X. (1984): "The international transmission of inflation to a small open economy under fixed exchange rates and highly interest sensitive capital flows", *European Economic Review,* Vol. 25, pp. 187-212.

Callan T. and J. FitzGerald (1989): "Price determination in Ireland: Effects of changes in exchange rates and exchange rate regimes", *The Economic and Social Review*, Vol. 20, No. 2, pp. 165-188, January.

De Gregorio, J., A. Giovannini and H. Wolf (1994): "International evidence on tradables and nontradables inflation", *European Economic Review*, Vol. 38, pp. 1225-1244.

Dennis, R. (1995) "Structural ECMs: What they are and should we be using them ?" Reserve Bank of New Zealand, Research Note N95/11.

Doornick, J.A. and D.F. Hendry (1994): PcFiml 8.0: Interactive Econometric Modelling of Dynamic Systems, (London: International Thomson Publishing).

Dornbusch, R. (1976) "Expectations and Exchange Rate Dynamics", *Journal of Political Economy,* Vol. 84, No. 6, pp. 1161 - 1176.

Edgren, G., K.O. Faxen and C.E. Odhner (1973): Wage Formation and The Economy, (London: Allen and Unwin).

Flynn J. (1986): "A simulation model of the effects of exchange rate changes on inflation and the trade balance", *Central Bank of Ireland Quarterly Bulletin*, pp. 103-118, Summer.

Fountas S., B. Lally and J. Wu (1995): "The relationship between inflation and wage growth in the Irish economy", Department of Economics, University College Galway, Working Paper No. 6.

Franz, W. and R.J. Gordon (1993): "German and American wage and price dynamics: Differences and common themes", Centre for Economic Policy Research, Discussion Paper No. 777, June.

Froot, K.A. and K. Rogoff (1995): "Perspectives on PPP and long-run real exchange rates", in G. M. Grossman and K. Rogoff (eds.), Handbook of International Economics, Volume 3, pp. 1647-1688, (Amsterdam: North-Holland).

Geary P.T. (1976a): "World prices and the inflationary process in a small open economy - the case of Ireland", *The Economic and Social Review,* Vol. 7, No. 4, pp. 391-400.

Geary, P.T. (1976b): "Lags in the transmission of inflation : Some preliminary estimates", *The Economic and Social Review,* Vol. 7, No. 4, pp. 383 - 389.

Geary, P.T. and R.M. Jones (1975): "The appropriate measure of unemployment in an Irish Phillips curve", *The Economic and Social Review,* Vol. 6, June, pp. 55-63.

Hamilton, J.D. (1994): Time Series Analysis, (Princeton: Princeton University Press).

Hansen, H. and K. Juselius (1995): CATS in RATS Version 1.00 - Installation and Use Guide, (Illinois: Estima).

Harris, R.I.D. (1995): Using Cointegration Analysis in Econometric Modelling (London, Harvester Wheatsheaf).

Honohan P. and J. Flynn (1986): "Irish inflation in EMS", *The Economic and Social Review*, Vol. 17, No. 3, pp. 175-191, April.

Johansen, S. (1988): "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, Vol. 12, pp. 231-254.

Johansen, S. (1991): "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models", *Econometrica*, Vol. 59, pp. 1551-1580.

Johansen, S. and K. Juselius (1990): "The full information maximum likelihood procedure for inference on cointegration - with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169-210.

Johansen, S. and K. Juselius (1992): "Testing structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for UK", *Journal of Econometrics*, Vol. 53, pp. 211-244.

Johansen, S. and K. Juselius (1994): "Identification of the long-run and the short-run structure - An application to the ISLM model", *Journal of Econometrics*, Vol. 63, pp. 7-36.

Johnson, H. (1972a): Inflation and the Monetarist Controversy, (Amsterdam: North Holland).

Johnson, H. (1972b): "Secular inflation and the international monetary system", *Journal of Money, Credit and Banking*, Vol. 5, No. 1, pp. 509-519, February.

Kenny, G. and D. McGettigan (1996): "Traded, non-traded and aggregate inflation in Ireland", Central Bank of Ireland, Technical Paper 3/RT/96.

Leddin, A. (1988): "Interest and price parity and foreign exchange market efficiency: The Irish experience in the European Monetary System", *The Economic and Social Review*, Vol. 19, No. 3, pp. 215-231, April.

Leddin A. and D. Hodnett (1995): "Purchasing power parity: Evidence from the Irish economy, 1922-92.", *mimeo.*, University of Limerick.

Lindbeck, A. (1979): "Imported and structural inflation and aggregate demand: The Scandinavian model reconstructed", in A. Lindbeck (ed.), Inflation and Employment in Open Economies - Studies in International Economics, Volume 5., pp. 13-40, (Amsterdam: North-Holland).

Mellis, C. (1993): "Tradeable and non-tradeable prices in the UK and EC: Measurement and explanation", Bank of England Working Paper Series, No 15.

O'Connell, T. and J. Frain (1989): "Inflation and exchange rates: A further empirical analysis", Central Bank of Ireland Technical Paper 1/RT/89, April.

Rowlatt, P.A. (1992): Inflation, (Chapman and Hall: London).

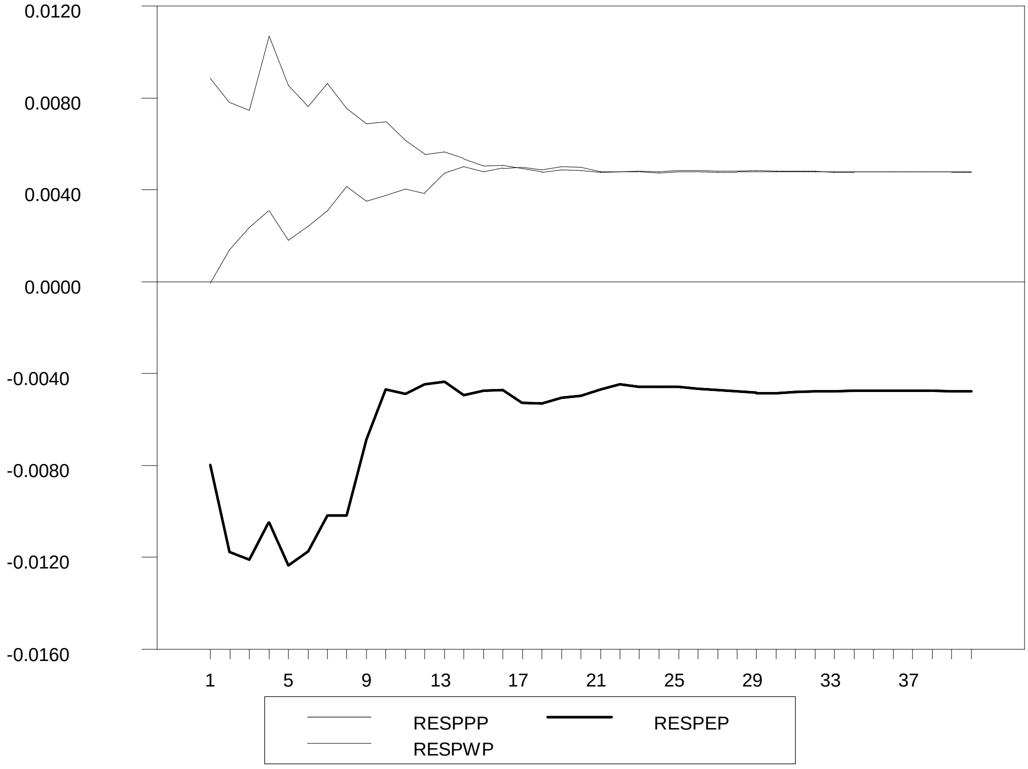
Thom, R. (1989): "Real exchange rates, co-integration and purchasing power parity: Irish experience in the EMS", *The Economic and Social Review*, Vol. 20, No. 2, pp. 147-164, January.

Wright, J.H. (1993): "Quantifying the non-stationarity in Irish real exchange rates", *The Economic and Social Review*, Vol. 25, No. 1, pp. 109-119, October.

Wright, J.H. (1994): "A co-integration based analysis of Irish purchasing power parity relationships using the Johansen procedure", *The Economic and Social Review*, Vol. 25, No. 3, pp. 261-278, April.

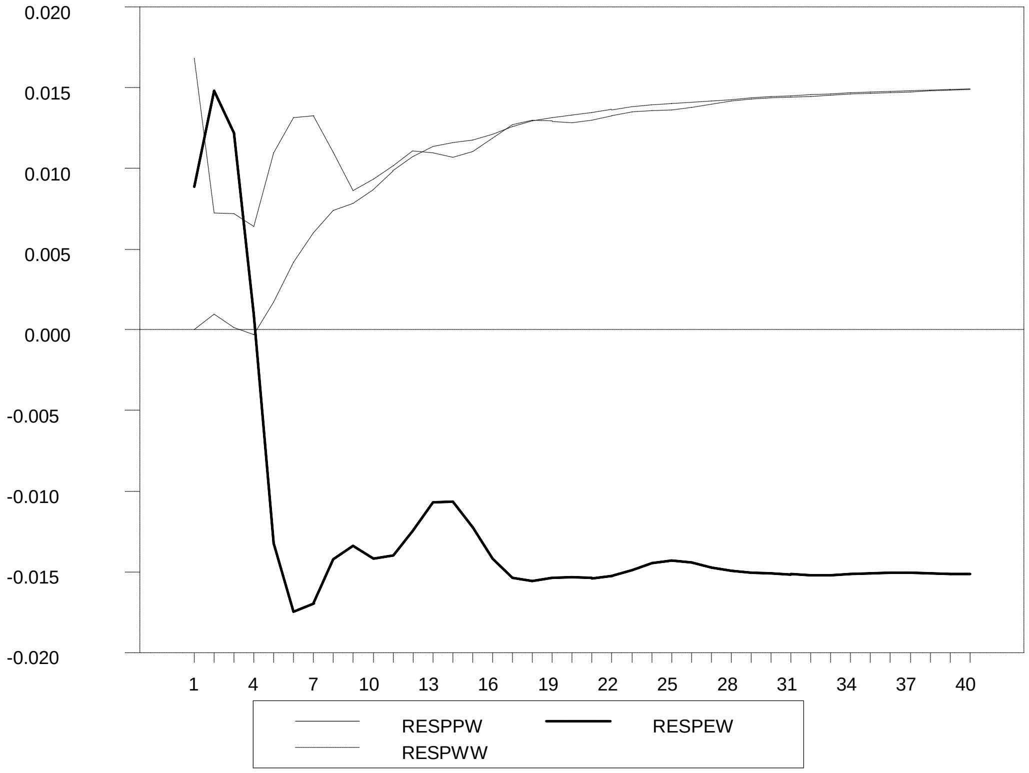
Appendix A: Impulse Response Functions

Figure A.1: Responses to Price Shock - Traded Price System



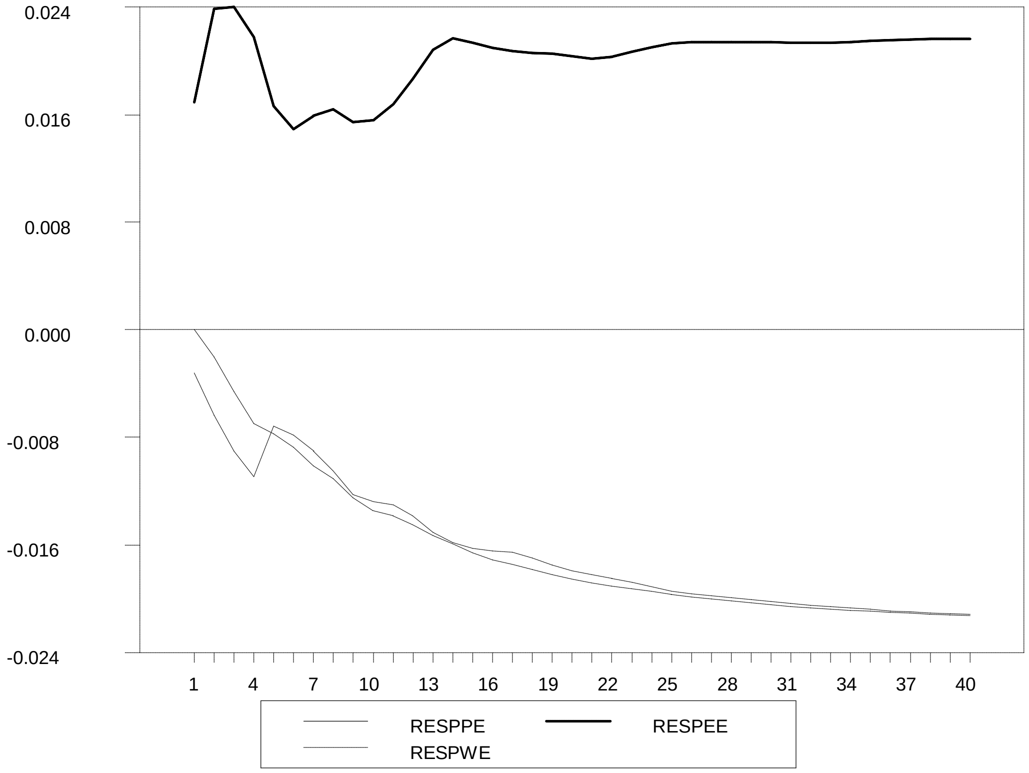
- *RESPPP: Response of traded prices to a traded price shock*
- *RESPWP: Response of wages to a traded price shock*
- *RESPEP: Response of the exchange rate to a traded price shock*

Figure A2: Responses to Wage Shock - Traded Price System



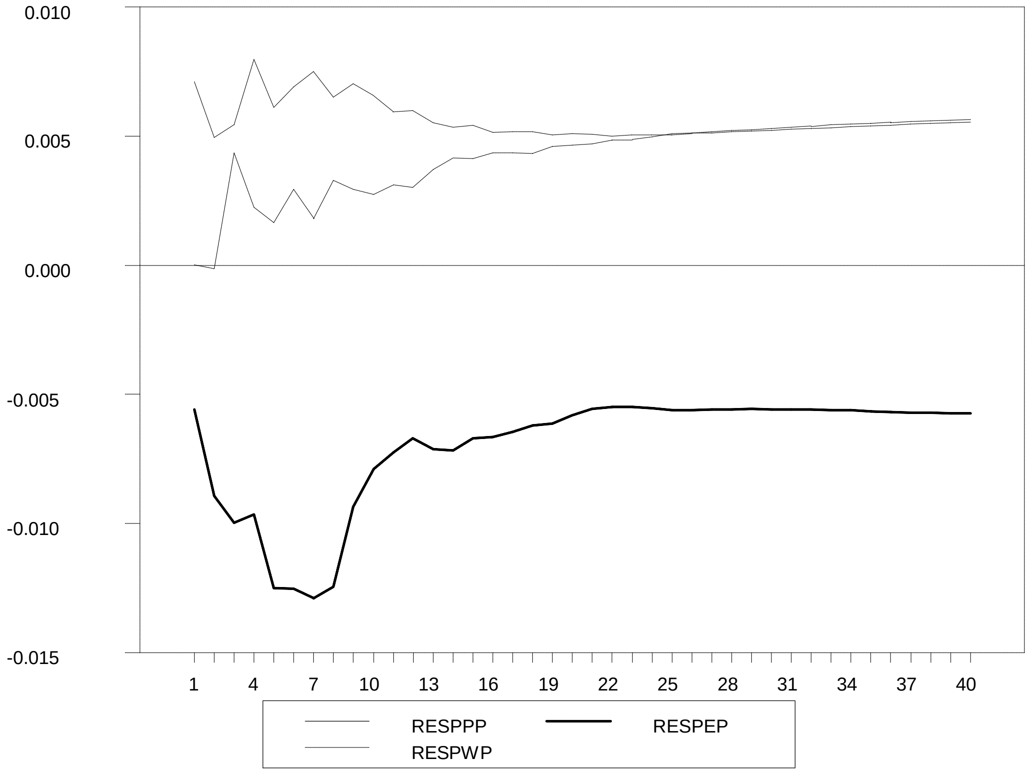
- *RESPPW: Response of traded prices to a wage shock*
- *RESPWW: Response of wages to a wage shock*
- *RESPEW: Response of the exchange rate to a wage shock*

Figure A3: Responses to Exchange Rate Shock - Traded Price System



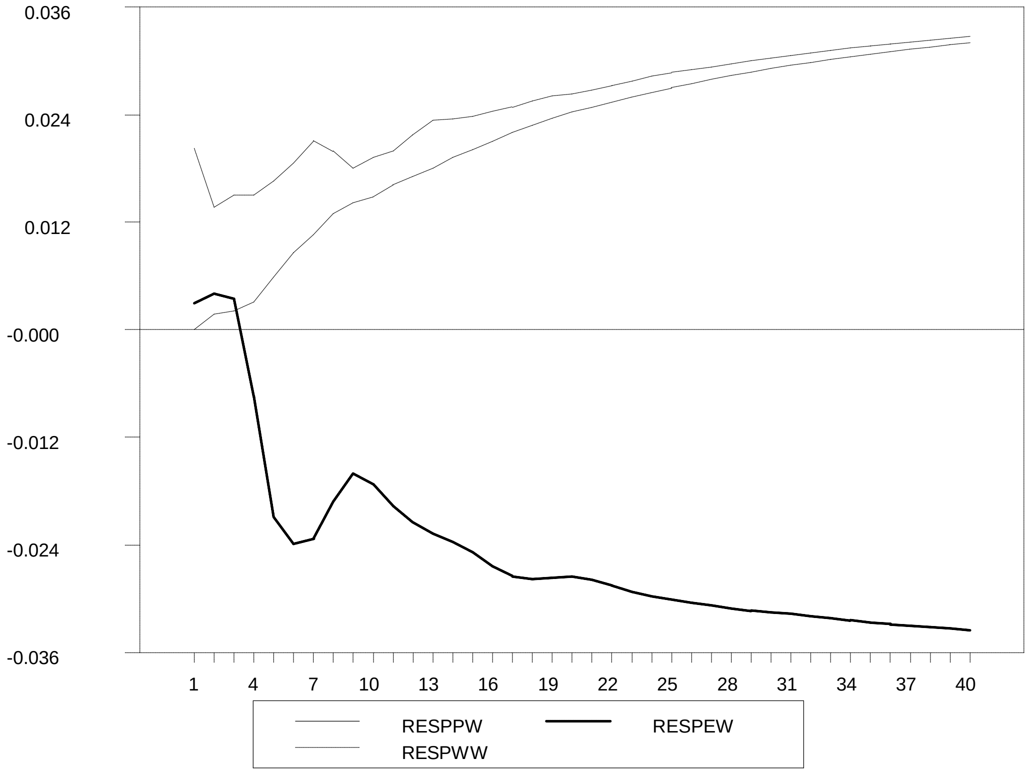
- *RESPPE: Response of traded prices to an exchange rate shock*
- *RESPWE: Response of wages to an exchange rate shock*
- *RESPEE: Response of the exchange rate to an exchange rate shock*

Figure A.4: Responses to Price Shock - Aggregate Price System



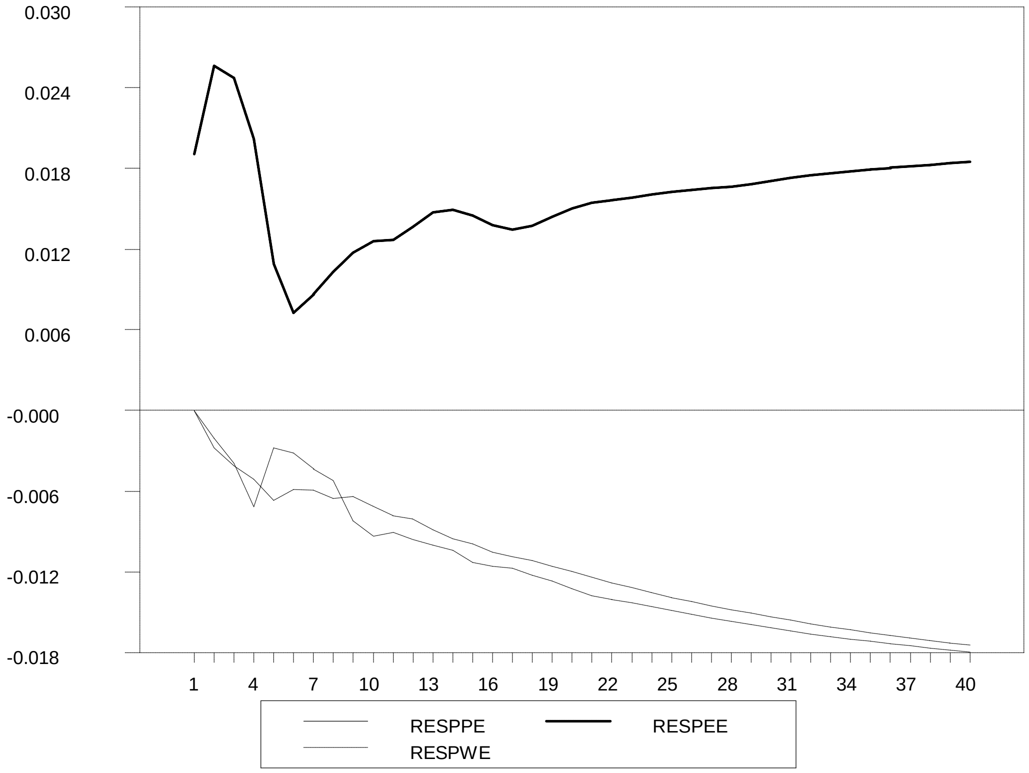
- *RESPPP: Response of aggregate prices to an aggregate price shock*
- *RESPWP: Response of wages to an aggregate price shock*
- *RESPEP: Response of the exchange rate to an aggregate price shock*

Figure A5: Responses to Wage Shock - Aggregate Price System



- *RESPPW: Response of aggregate prices to a wage shock*
- *RESPWW: Response of wages to a wage shock*
- *RESPEW: Response of the exchange rate to a wage shock*

Figure A6: Responses to Exchange Rate Shock - Aggregate Price System



- *RESPPE: Response of aggregate prices to an exchange rate shock*
- *RESPWE: Response of wages to an exchange rate shock*
- *RESPEE: Response of the exchange rate to an exchange rate shock*

Data Appendix

Aggregate Prices: Underlying Consumer Price Index, i.e. headline CPI net of the impact of the mortgage interest component. The relevant weights, the headline CPI and the Mortgage Interest component were obtained from the CSO.

Traded Prices: See **Construction of Disaggregated Price Indices** below.

Non-Traded Prices: See **Construction of Disaggregate Price Indices** below.

World Traded Prices: Computed as the weighted average of the UK and German Wholesale Prices. Source: IFS databank. In aggregating the two series, the UK WPI received a weight equivalent to the share of the UK in Irish trade and the German WPI received a weight equal to one minus the UK share. The share of the UK in Irish trade was obtained from the CSO trade statistics.

Exchange Rate: The nominal Effective Exchange Rate Index. Note that the way in which the exchange rate is measured means that an <u>increase</u> in its value is associated with an <u>appreciation</u>. Source: Central Bank of Ireland.

Wages: Index of average weekly earnings in Manufacturing Industries. Source:CSO.

Construction of Disaggregated Price Indices
The data series employed in the construction of the traded/non-traded price series were obtained from the CSO. The decomposition of aggregate prices reflects economic intuition concerning certain goods (e.g. highly perishable commodities and some "public goods") which may fall into the non-traded category. Equally, it takes account of some items which are classified under Services but which could reasonably be deemed to be traded (e.g. Expenditure Abroad). The series were built up from individual sub-indices of the CPI. The classification of these sub-indices in terms of the traded and non-traded categories is outlined in the Table below. The Table also provides the relevant weights for traded and non-traded sectors based on their shares in the underlying consumer price series. In the actual aggregation of individual sub-indices into traded and non-traded components, the weights were allowed to vary according to the changes introduced by the CSO in 1975, 1982 and 1989. For example, the weight attributed to the non-traded sector rose steadily over the sample period from 27.8% in 1975 to 29.6% in 1982 and to 33.6% in 1989. In part, this reflects the growing weight attached to non-traded services and non-traded transportation goods and services. To avoid the problem of compounding a base effect with a significant change in the weight, the individual sub-indices were

broken down into the three sub-periods, i.e. 1975:Q4 - 1982:Q4, 1982:Q4 - 1989:Q4 and 1989:Q4 - 1995:Q3. Each series was then rebased to equal 100 at the beginning of each sub-period and the appropriate weights were applied to each series. Whole sample traded and non-traded price series could then be calculated by linking the weighted series for each sub-period. Lastly, the resulting traded and non-traded price indices were then rebased to equal 100 in 1989 Q4.

Disaggregated Price Series	**Weight(%)**		
	1975	1982	1989
Non-Traded Prices			
- Non-Traded Food (Bread, Fresh Milk, Eggs, Meals Out)	7.9	6.8	7.9
- Fuel and Light	6.0	6.3	6.1
- Housing net of Local Authority Charges, Mortgage Interest, Repairs and Decorations	1.7	1.5	2.2
- Non-Traded Transport (Motor Tax and Registration, Motor Insurance, Repairs and Maintenance, Other Vehicle Costs, Bus Fares, Train Fares, Other Travel)	4.0	4.7	4.7
- Services net of the Expenditure Abroad	8.1	10.3	12.7
	27.8%	29.6%	33.6%
Traded Prices			
- Food net of Bread, Fresh Milk, Eggs, Meals Out	23.1	18.8	18.8
- Alcoholic Drink	11.7	12.6	12.2
- Tobacco	4.5	3.5	3.5
- Clothing and Footwear	11.0	8.3	7.0
- Repairs and Decorations	2.0	1.7	1.5
- Household Durables	4.9	5.2	4.9
- Other Goods	5.3	5.8	6.1
- Traded Transport(Motor Cycles, Motor Cars, Other Vehicles, Motor Fuel, Motor Oil, Spare Parts)	9.5	12.4	9.6
- Expenditure Abroad	0.03	2.00	3.0
	72.2%	70.4%	66.4%